

MAKING TEMPORARY REPAIR PLANNING FOR SHIP EQUIPMENT BASED ON CONDITION AND MISSION

ZHANG Ying-feng¹ JIN Jia-shan² HUANG zheng²

(1 Naval Unit No.92854, Zhanjiang 524064, China)

(2 Department of Power Engineering, College of Naval Architecture and
Power, Naval University of Engineering, Wuhan 430033, China)

Abstract

The paper discusses properties of temporary repair plan for ship equipment. To satisfy the mission reliability of ship, a series of principles and methods used to confirm repair items are proposed by analyzing facility's fault probability during the mission and component's residual life. Also they can direct the making of temporary repair plan.

Keywords: technical condition, mission reliability, residual life, ship, temporary repair plan

Temporary repair is an important method of ship equipment technical management, especially before one mission, the ship needs repair generally. There are such repair items as repairing occurred faults, taking preventive maintenance to faults that are likely to occur in the mission, which could prevent faults from occurring and insure ship mission successful. In a word, temporary repair aims to make ship possess or restore its technical condition which can achieve the mission.

Considering temporary repair's limited time and cost, it's impossible and sometimes unnecessary to repair all broken-down equipments or equipments with technical condition degraded. Especially for ships to be repaired in the factory, some broken-down equipment that wouldn't work in the mission needn't be arranged in the temporary repair plan but to be remitted to the factory's repair. Thus, it need confirm whether equipment need repair, how to repair them and what repair items to be done, then we can make proper temporary repair plan.

Mission reliability is an index measuring whether ship could accomplish its mission, and on the condition of insuring ship mission reliability, proper temporary repair plan only arranges repairing equipment related with mission, then repair time and cost could gain better expense benefit. The paper will discuss how to confirm repair items according to mission reliability.

1 Basic idea

Since mission reliability could quantitatively measure whether ship accomplishes its mission, it would

be the primary gist of operations and maintenance decision. That is to say, that ship need repair is because it couldn't provide the needed least equipment bill for mission, or there is such right least equipment listing at the beginning however, the subsequent occurred faults in the mission would destroy the least equipment listing and it will not meet ship's mission reliability finally.

Maintenance aims at material equipment on the ship. Obviously, for equipment which is associated with mission nearly, it must need repair if it is broken-down before temporary repair, whereas for equipment which isn't broken-down before temporary repair, its fault probability is biggish during the mission and its mission reliability determine the whole ship mission reliability, so we must need calculate ship mission reliability by anticipating equipment mission reliability and determine whether to repair the equipment. Furthermore proper temporary repair plan must insure ship mission reliability after repairing itself.

To analyzing equipment mission reliability, firstly we must analyze ship missions, decompose them and transform them into material function demand on equipment, then confirm the fault judge rule at the same time; secondly we should establish equipment mission reliability model and confirm input data including current condition of equipment (considering already working hours primarily), mission time and so on.

2 Ship mission analysis and confirmation of fault judge rule

Generally, ship navigation is to accomplish one mission. In order to study mission reliability, we must analyze and decompose ship mission, then confirm fault criterion. Mission profile^[1] is the powerful method to analyze mission such as ship mission process of battling sea (see Figure 1).

prepare	navigation	battle	withdraw	return
2 days	4 days	8h	12h	8 days

Figure 1 fictitious mission profile of battling sea

Only by equipment achieve the ship function demand, can ship accomplish the mission. Therefore,

equipment function demand is determined by mission, for example, the power engine function demand is to provide enough power which insure ship navigation in a stated speed and provide needed energy for other equipment. And this kind of function demand must be quantificational. In short, take power engine for example, if mission demands ship navigation above speed of 24 kts, total power would be above 2000 horsepower.

Through analyzing ship mission profile of Figure 1, we could get every phase power demand of power engine (see Figure 2).

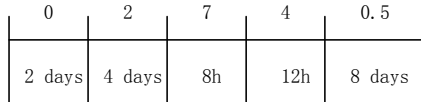


Figure 2 power demand of power engine (ten thousand horsepower)

Based on the confirmation of function demand, we could confirm the fault judge rule farther: on any mission phase, that power engine can't emit stated power will consider fault, that is, on any time of phase 1, total power of power engine is less than 20 thousand horsepower; on any time of phase 2, total power of power engine is less than 70 thousand horsepower; on any time of phase 3, total power of power engine is less than 40 thousand horsepower; and on any time of phase 4, total power of power engine is less than 5 thousand horsepower and otherwise.

3 Mission reliability model of equipment

On the condition of exchanging the fault parts in time to restore its normal, complex equipment with a few parts will always keep a permanent fault rate after it passes through the circle of operation, fault, exchange and operation many times without domination fault mode. That is, mean time between failures will obey exponential distributing^[2]. This theory has an important effect on calculating superior system reliability, but it isn't apt to use the theory on the material equipment's operation and maintenance, and makes errors sometimes.

Generally speaking, we should line out its reliability logic block diagram firstly when the mission reliability model of ship equipment is established, then confirm relation of mission reliability between equipment and components. Secondly we should establish calculation model of components operation reliability. Thus equipment mission reliability model is established.

As a rule, equipment reliability logic block diagram is very complex; but it is composed of structure

connected in series and structure in parallel mostly, sometimes including cold and hot reservoir. While the function demand is different, structure connected in series could change into structure connected in parallel or reservoir. For example, if steam power independence group is composed of two boilers and one steamer, full burden operation demands that two boilers must provide steam amain to insure enough steam for steamer, thus the independence group will be a kind of structure connected in series; but if it demands half power, the reliability block diagram is composed of one steam connected in parallel with two boilers connected in series. Also, a suit of equipment reliability block diagram may be different because of different function demand. So we must ravel function demand before confirming the reliability block diagram.

As regards all components of complex equipment, they don't obey exponential distributing, such as bearing life, which could obey Weibull distributing; and mean time between failures would obey normal school or logarithm normal school. However equipment mission reliability is determined by nonoccurrence fault probability (operation reliability), therefore we should calculate equipment mission reliability according to components operation reliability.

If one component life obeys Weibull distributing, its distributing function is

$$F(t)=1-\exp(-(t/\eta)^m)$$

The component fault probability between t_1 and t_2 is

$$F=F(t_2)-F(t_1)=\exp(-(t_1/\eta)^m)-\exp(-(t_2/\eta)^m)$$

Suppose the time that the component has been working is t_1 and it is normal when the mission is beginning, fault probability between t_1 and t_2 is

$$\lambda=F/R(t_1)=1-\exp(-(t_2/\eta)^m)+(t_1/\eta)^m)$$

Then the component reliability is

$$R_M=1-\lambda=\exp(-(t_2/\eta)^m)+(t_1/\eta)^m)$$

After the component reliability is calculated, we could calculate the equipment mission reliability by the equipment mission reliability model, thus we could calculate ship mission reliability.

4 Components residual life

Most machine components failure belong to interference model^[3]. With machine components using, their shape dimension tapers as a result of abrasion and cauterization etc, which depress their intensity consequently, also components failure probability increase continuously with interference area enlarging. In order to analyze when one component is failure, we

discuss one simple case. Suppose both stress and intensity is not a random variable, stress equals constant s and intensity degradation rule is simulated by exponential hypotaxis, that is $\sigma=A+Be^{ct}$. At the very start new components' σ is bigger than S , it will be decrescent with operation; if σ equals S , components will be failure at the critical time, that is, when $t=\ln((S-A)/B)/C$, components will be failure.

Therefore, when mission begins, if the component has been operating period of time t_1 , its residual life is $t-t_1$. And conclusions will be got as follows:

① If both stress and intensity is random variable, average value is μ_σ and μ_s , components fault probability would be 50 percent when $\mu_\sigma=\mu_s$. Therefore, controlling the fault probability would bring us components limit operation time, and then confirm its residual life.

② As we all know, components intensity would be related to degree of cauterization and abrasion etc, although components average life t could be got from a great deal of statistic data, material component residual life may be not $t-t_1$ after operation period of time t_1 . Obviously, when components average quantity of cauterization and abrasion is δ_1 at the time t_1 and material component average quantity of cauterization and abrasion is δ_1' , the component residual life may be bigger than $t-t_1$ on the condition of $\delta_1 > \delta_1'$. Generally, we could get component biggest permit quantity of cauterization and abrasion δ by stress calculation, then by δ and testing δ_1' , material component residual life would be got, finally confirm whether it need repair or change before mission.

5 Making of temporary repair plan

After completing all the above tasks, we could make temporary repair plan, all equipment that don't satisfy mission reliability and components whose residual life can't reach mission time should be repaired temporarily to accomplish ship mission except broken-down equipment connected with mission.

Besides, temporary repair plan should keep all appointed temporary repair items accomplished on schedule. We should organize and carry out the plan well, and strengthen arrangement of personnel, data, spare parts, equipment etc. Also we should attemper them in reason to insure them unoccupied nor crowd, and finally gain better expense benefit from the devoted time and cost.

Reference

[1] LUO yun, JIN jia-shan, YU jun, etc. Equipment reliability arrangement—methods and procedure[M]. Wuhan: Hubei science technical press, 1992.

[2] CHEN xue-chu. Modern maintenance theory[M]. Beijing: National defence factory press, 2003, 1.

[3] Equipment maintenance Council of Province Sichuan machine engineering academy. Machine reliability[M]. Chengdu: Sichuan people press, 1983.

作者联系方式: 金家善, 电话 02783443364,
传真, E-Mail: ZSXLCC@163.COM。